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The US Army Corps of Engineers Roadmap for Life-Cycle Building Information Modeling (BIM)

Supplement 1 – BIM Implementation Guide for Military Construction (MILCON) Projects Using the Autodesk Platform

Prepared by Autodesk, Inc.

111 McInnis Parkway
San Rafael, CA 94903

November 2012

Engineer Research and
Development Center

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Final report

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Abstract

Building Information Modeling (BIM) technology has rapidly gained acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge for the US Army Corps of Engineers (USACE) is to extend BIM use beyond its basic labor- and time-saving benefits to become a fully realized information network that permanently transforms conventional business processes to unprecedented levels of efficiency and organization.

This document describes the current USACE strategic plan, reflecting progress made toward the goals of the original 2006 USACE BIM roadmap as published in Engineer Research and Development Center (ERDC) Technical Report TR-06-10 (October 2006). This update of the strategic roadmap focuses on fuller integration of BIM technologies into USACE planning, design, construction, and operations and maintenance (O&M) processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is BIM implementation within the business processes of the Military Construction (MILCON) and Civil Works programs, including processes for working with USACE industry partners and software vendors.

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Preface

This document was prepared for Headquarters, US Army Corps of Engineers (HQUSACE), as a supplement to Engineer Research and Development (ERDC) Special Report SR-12-2, *The US Army Corps of Engineers Roadmap for Life-Cycle Building Information Modeling (BIM)* (November 2012). The text was authored by Autodesk, Inc., San Rafael, CA, for government personnel, contractors, and stakeholders using the Autodesk Revit platform on Military Construction (MILCON) projects supervised by USACE. This supplement is a reprint of the original edition, dated April 2010, but is revised to include accurate cross-references to the USACE 2012 updated BIM Life-Cycle Roadmap. This publication reflects a vendor-neutrality policy in support of commercial partners involved in USACE BIM implementation and project execution. Supplements pertaining to other vendors' technology products for MILCON and Civil Works projects are available or are in preparation. The proponent for the USACE Building Information Modeling Roadmap is the Directorate of Civil Works, Engineering and Construction Branch. The Technical Monitor is Jason C. Fairchild, CECW-CE.

Development and update of this guide were coordinated through the Engineering Processes Branch (CF-N) of the Facilities Division (CF), US Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC-CERL); and the CAD/BIM Technology Center (IS-C) of the Software Engineering and Informatics Division (IS), Information Technology Laboratory (ERDC-ITL). At the time of publication, Donald K. Hicks was Chief, CEERD-CF-N; L. Michael Golish was Chief, CEERD-CF; Dr. Kirankumar Topudurti was the Deputy Director; and Dr. Ilker Adiguzel was the Director of ERDC-CERL. Edward L. Huell was Chief, CEERD-IS-C; Ken Pathak was Chief, CEERD-IS; Dr. Kevin M. Barry was the Acting Deputy Director; and Dr. Reed L. Mosher was the Director of ERDC-ITL.

The following individuals are acknowledged for their contributions to the preparation and technical review of this report:

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- Hai Le, CESAM-EN-D; Roger Fujan, CENWO-ED-C; and Wayne Stiles, CELRL-ED-D-S (Engineer District BIM Managers).

COL Kevin J. Wilson was the Commander of ERDC, and Dr. Jeffery P. Holland was the Director.

Document Terminology

In this document, the term *USACE Roadmap*, or simply *Roadmap*, refers to the US Army Corps of Engineers Roadmap for Life-Cycle BIM Implementation.

The term *soft copy* refers to digital files and documents.

Open source files are referred to as *universal files*.

Important Revit-specific terms are italicized on first use, and sometimes elsewhere where required for clarity.

The acronyms and abbreviations used in this document are listed below.

ACE-IT:	Army Corps of Engineers–Information Technology
AEC:	Architectural, Engineering, Construction
AOT:C	Autodesk Official Training Courseware
AVI:	Audio Video Interleaved
BIM:	Building Information Modeling
CAD:	Computer Aided Design
COBie:	Construction Operations Building information exchange
DVD:	Digital Versatile Disc (formerly Digital Video Disc)
DWF:	Design Web Format
ELA:	Enterprise License Agreement
FM:	Facilities Management
FTP:	File Transfer Protocol
IFC:	Industry Foundation Class
LEED:	Leadership in Energy and Environmental Design
MEP:	Mechanical, Electrical, & Plumbing
O&M:	Operations and Maintenance
ODBC:	Open Database Connectivity
QA:	Quality Assurance
QC:	Quality Control
RFI:	Request for Information
USACE:	US Army Corps of Engineers
VPN:	Virtual Private Network

1 Introduction

1.1 Background

This document was authored by Autodesk, Inc. It is intended for government personnel, contractors, and stakeholders using Autodesk Revit on Military Construction (MILCON) projects supervised by USACE. The intent of the document is to ensure that users have the information needed to comply with the Building Information Modeling (BIM) implementation and business transformation goals established by Headquarters, USACE. Incorporating industry best-practice recommendations, this reference guide explains how Autodesk Revit can be applied on a construction project while supporting USACE goals and objectives for life-cycle BIM implementation.

This November 2012 edition of the Autodesk, Inc., implementation guide is identical to the original edition of April 2010 except for updates of ERDC administrative content and cross-references to associated USACE documents and websites. As such, this edition supersedes the 2010 version and should be used in its place.

1.2 About Supplement 1

Supplement 1: BIM Implementation Plan for Military Construction Projects Using the Autodesk Platform, provides an overview of the Revit system, demonstrating how the application can be used on a USACE project in a USACE environment. Suggestions are provided about projects where design services are outsourced to the private sector. This supplement is published as a "living document," so it will be revised to reflect significant changes in technology and construction industry requirements.

Documentation of processes comprising the Revit workflow are the core content of this reference guide. The content addresses how Revit can be used specifically to address USACE BIM Roadmap vision and mandates. The intended scope of this document is to outline best practices and to introduce users to Revit's unique functionality. It is not intended to serve as a Revit user's manual or as a substitute for training.

1.3 Revit Overview

The Revit software suite was created to design and coordinate architectural, structural, mechanical, electrical, and plumbing disciplines in a BIM environment, using parametrics with bidirectional associativity. Within Revit, the goal is not simply to build geometry but to establish the relationships upon which geometry is built.

Revit is designed for application to a wide range of project delivery methods, facility types, and project scales. Autodesk's integrated products are fully capable of supporting the varied and complex requirements of USACE projects.

1.3.1 Parametric Capability

There are three main classes of *elements* in any building design Revit model:

- building components — walls, roofs, doors, windows, floors, etc.
- views — models, schedules, sheets, etc.
- annotations — text notes, dimensions, spot elevations, etc.

The Revit database provides full bidirectional associativity between all three element classes and allows the Revit platform to perform in a logical, intuitive, and streamlined fashion. Revit users are able to create extremely accurate and highly detailed plans and document libraries (data repositories) for each project, from inception through completion.

A parametric database using bidirectional associativity (or dynamic interaction) enables simultaneous automatic data modification at every level. For example, because there is a pre-established relationship between windows and walls in a building design, when a wall is moved in Revit, the associated window automatically moves with it. This approach to modeling ensures that minimal effort is required to set up, organize, and update or maintain the project environment.

1.3.2 Bidirectional Associativity

The Revit model creates and maintains relationships between the building elements, and then, between those elements and the associated drawings and sheets. A change made in any view will propagate that change in all

other views, applied to every component, view, and annotation related to it including all sheets and schedules. If a callout detail is moved from one sheet to another, the sheet number information in the callout bubble will automatically update. When a section mark is flipped, all views related to that section update. When a wall is added in the plan, it appears on elevation, section, and other views, including material takeoff charts. A change in a door or window type propagates through all the graphical and non-graphical views in an integrated manner. Listed below are several examples of bidirectional associativity and corresponding parametric capability from one class element to another:

- *Building components to building components*. Move one wall and connected adjacent walls adjust to become longer or shorter. Move walls and the floor adjusts to cover the area enclosed by walls.
- *Building components to views*. Change to a building component is automatically reflected in all graphical views without additional user actions. Move walls and the room schedule updates room area calculations.
- *Building components to annotations*. Change geometry and dimension value updates. Move things higher or lower and spot elevation reflects new heights.
- *Views to building components*. Any graphical view (plan, elevation, section, callout) may be used to effect a change to building components. Changes to building components may be made by editing their parameters in schedules.
- *Views to other views*. Move section or detail views backward or forward and callouts move with their parent section. View and drawing schedules (view/drawing lists) may be used to change properties of other views and drawing.
- *Views to annotations*. Change view scale and all annotations (dimensions, text notes, etc.) adjust to maintain their sizes on printed output. Place a view on a drawing sheet and view tags update to reflect sheet number.
- *Annotations to building components*. Change dimension values and building components change accordingly. Changes to property values shown by tags automatically propagate to building components.
- *Annotations to views*. Flip direction of section view tags and the view forward direction flips.

- *Annotations to annotations*. Change sheet number in a *titleblock* and the change will propagate through drawing to views placed on this drawing and then to their view tags (section and callout heads).

2 Revit Implementation Workflow

The Revit implementation workflow is organized in five phases that guide and support the building project life cycle (see Figure 1):

- *Phase One — Logistics*. Software license acquisition and hardware/software setup, staff requirements identification and training, and overall preparation.
- *Phase Two — Initialization*. Project setup, including planning and data management. In this phase, the Revit strategy is determined — choices and decisions are made, and the team members are assigned and mobilized.
- *Phase Three — Model Management*. The design and modeling phase. The structures are designed and modeled, and quality controls are then applied.
- *Phase Four — Deliverables*. The creation and printing of project deliverables.
- *Phase Five — Life Cycle*. The final cycle involves project archiving, data library updates, commissioning, and operations and maintenance.

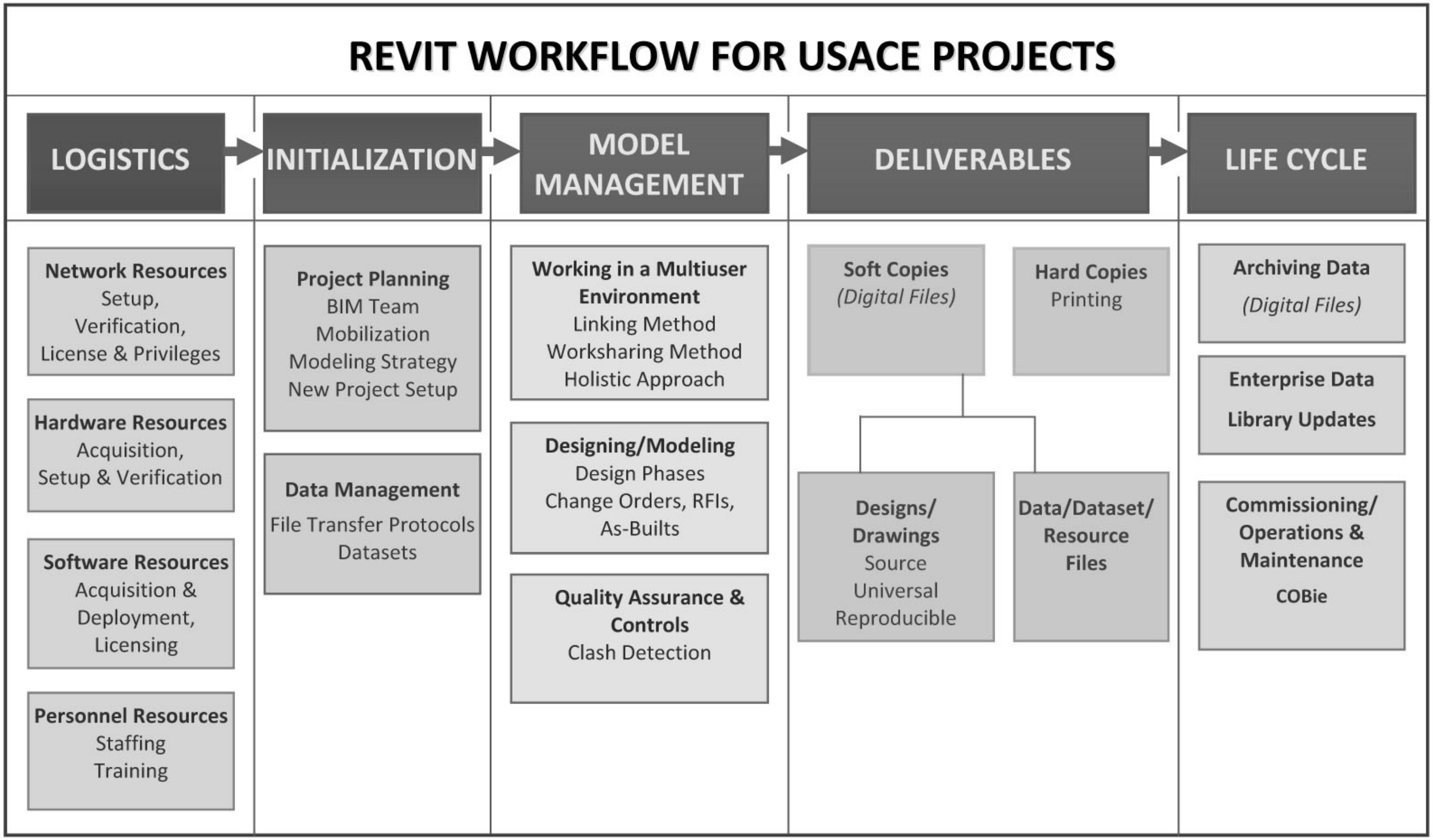

Figure 1. Revit workflow for Army Corps of Engineers BIM projects.

2.1 Logistics

Logistics, the first phase of the workflow, involves acquiring, assessing, setting up, and preparing resources for the BIM project initialization. This section will guide the user in preparing the work environment for a Revit project.

A successful implementation of Revit, as with any software application, requires planning to verify, evaluate, and address hardware, software, network, and personnel needs.

Technical support requirements, protocols, and contacts should be established. With the subscription program, users are entitled to web-based product support directly from Autodesk.

2.1.1 Network Resources

Verify and determine that network resources are in place for the team. Verify and determine Revit file sharing and file transfer protocols (FTPs) for different file formats among all project participants via data management server, email attachment, or posting to FTP or virtual private network (VPN) sites.

Set up appropriate network access rights and privileges for users and BIM managers.

2.1.2 Hardware Resources

Review BIM server, backup server, and individual workstation setup with the Army Corps of Engineers Information Technology (ACE-IT) activity. Acquire hardware as required. Platform requirements are summarized in Table 1.

Verify that hardware, including desktop, mobile computer, monitor, mouse, printer/plotter, media, and other components, is compatible with the complete Revit platform (architecture, structure, mechanical/electrical/plumbing [MEP], and other related software).

Table 1. System recommendations for Revit.

Description	Requirement
32-bit operating system	Microsoft Windows XP Microsoft Windows Vista 32-bit
64-bit operating system	Microsoft Windows XP Professional x64 Edition Microsoft Windows Vista 64-bit
Browser	Microsoft Internet Explorer 6.0 or later
CPU Type	Intel Core 2 Duo 2.4 GHz or equivalent AMD processor
Memory (32-bit OS)	4 GB RAM
Memory (64-bit OS)	8 GB RAM
Video display	1280 x 1024 monitor and display adapter capable of 24-bit color *
Hard disk	5GB free disk space
Pointing device	MS-mouse compliant
Media	Download or installation from DVD
Connectivity	Internet connection for license registration

* High-definition monitors may require additional video memory.

2.1.3 Software Deployment

Acquire and install Revit on the network or workstations required for the project. Revit applications can be deployed over a network or installed locally on individual workstations. Before deploying Revit, verify the compatibility of the computer-aided design (CAD) program and related applications used by project team. Verify that all installed software is functioning properly. Conduct a test run to verify Revit links to *library* resources.

The Autodesk license can be installed on a server. In the future, the Autodesk Enterprise License Agreement (ELA) with USACE will offer flexible concurrent licensing that allows access to multiple Autodesk products.

2.1.4 Personnel Resources

BIM team personnel may include project managers, BIM managers, designers, engineers, and other BIM users depending on project requirements. Determine the level of BIM experience and Revit training that will be required for project team members. Assign BIM team members for Revit training as required.

Revit software architecture was developed independently from the AutoCAD platform, and the use of Revit does not require proficiency with AutoCAD. Autodesk and approved agents offer Revit users various in-depth

training options, from classes to workshops to on-site mentoring. Training is available for different user levels and is designed to focus on specific functionalities and areas of work. Training covers Autodesk Revit and related applications for multiple disciplines (architecture, structure, and MEP). Programs can be more or less inclusive depending on the needs of USACE.

A sample training program for the USACE architectural, structural, and MEP staff disciplines is outlined in section 3.4. For all training modules, Autodesk will work with USACE to determine the appropriate Autodesk Official Training Courseware (AOTC) curriculum.

2.2 Initialization

Initialization requires making decisions about project planning and data management so the project can begin smoothly and progress seamlessly. During Initialization, the project scope and scale will be major factors in determining the strategy and defining roles. A clear understanding of the scope is necessary to determine the extent of detail and data required in the Revit model. The choices made in this phase will determine the required project parameters and will serve as both guidelines and quality controls. Once the Revit strategy has been determined, it should be communicated to all team members.

Establish technical support needs, protocols, and contacts. With the subscription program, users are entitled to web-based product support directly from Autodesk.

2.2.1 Project planning

a. Team Mobilization

Finalize roles and responsibilities of team members in relation to the project. Establish a clear communication methodology.

b. Modeling Strategy

To establish a comprehensive modeling strategy, determine the modeling and design coordination process, the extent of detail, and data that will be required in the model. Establish file saving, sharing, and transfer protocols. Determine the model management strategy (see section 2.3).

The modeling strategy for the project might include the following aspects:

- a design and model coordination process for continuous collaboration among disciplines during design phases
- *worksharing* and *workset* parameters
- settings and preferences for project units and tolerances
- data management, project folder structure, and file naming conventions
- deliverables and processes necessary for organizing and formatting deliverables
- extent of detail and data required in the model, as coordinated with contract requirements and conditions
- a clash-detection process, scope, and reporting criteria for quality assurance and quality control (QA/QC), possibly using Autodesk Navisworks.

c. Project Setup

Create a new template or transfer an existing Revit template from another project so that project documents have uniform and consistent style, format, and information. Revit uses a default template when a new file is opened. A Revit default template can create a project template file that can be used whenever a new project template has to be created.

A Revit project template can include more than the settings listed in Table 2. For example project-specific sheet titleblocks, formatted schedules, standard partition types, and family components are commonly part of a project template. Typical details can also be templates. Table 2 represents a partial inventory of settings that might be included in a template.

Table 2. List of representative settings in a template file.

Working Units (Metric/Imperial)	Named Views and Sheets
Colors	View Properties
Default Families Loaded	View Display
Line Styles	Fill Patterns
Lineweights	Material Definitions
Line Patterns	Object Styles
Time Date & Place	Export Layers Definitions
Annotation Text Note Leader Arrow	Use OpenGL Hardware Graphics
Dimension Style Parameters	View Templates
Annotation Symbol Styles	Partition Types
Default Loaded Tags	General Notes/Legends
Temporary Dimension Defaults	Drawing Titleblocks
Properly Formatted Schedules	Standard Details in Drafting Views
Custom Host Elements	Custom Stair/Railing Types

Project standards (including CAD standards) can easily be transferred to a new project template from previous projects or other projects under development. Open both project templates in the same Revit session. Click Manage Tab and select Transfer Project Standards. In the Select Items to Copy dialog box; select the source project to copy from; and check the standards to be transferred to the new project template. See Figure 2 for an illustration.

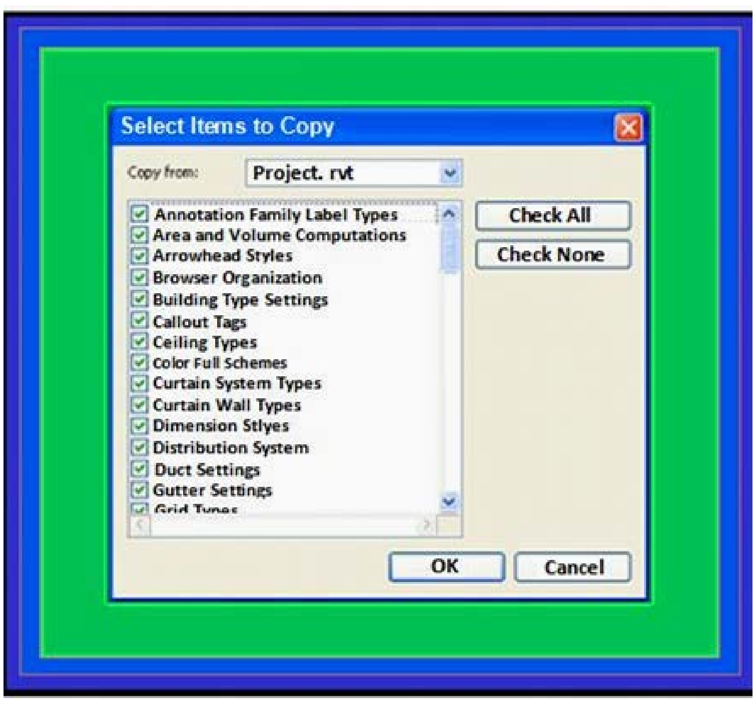

Figure 2. Transferring standards to a project template.

The transferred standards may be appended to the standards in the new project or they may replace/overwrite the new project standards. Standards may be transferred from any project to any other project, not only from an older project to a newer project.

d. *Design Options*

During the design phase it may be desirable to evaluate variations of a particular design idea or intent. The Design Options feature allows users to create multiple design alternatives simultaneously.

Each grouping of design alternatives is called an *option set*, and a Revit project may contain numerous option sets. Entrance features, reception areas, and tenant fit-outs are all examples of possible option sets.

e. *Building Relationships*

When creating and adding to a building model in Revit, the question to ask is, “How do building components, objects, and elements relate to each other in the building?” This is different from the traditional approach used for CAD representations. The question typically asked for CAD drawings was, “What is this supposed to look like when it is plotted?” For example, walls within Revit can have their height determined in one of two ways: either explicitly or related to upper and lower project levels. A wall can be either a fixed 8’ 0” height, or a dynamic height that would move with an associated level.

Drawing walls with an explicit height may be sufficient in the case of a dumpster enclosure because the height is unlikely to change. On the other hand, interior walls might grow or decrease in height if the floor-to-floor height changes. To accommodate potential dimensional variations, set only one constraint and allow Revit to determine the final geometry. As the elevation level changes, all the associated wall heights are modified accordingly. Revit manages geometric relationships automatically.

f. *Overconstrained Models*

Avoid overconstraining a model. Revit allows the user to create and lock relationships and alignments, and it can be tempting to lock every constraint. This is not advisable, especially during the early phases of a project, because excessive use of constraints will reduce flexibility. Elements

should only be locked or constrained when necessary for the design intent. For instance, it is sometimes prudent to lock the structural grid to prevent accidental manipulation.

2.2.2 Data Management

Data management addresses how design and data files are shared and transferred over the network and the web. Revit BIM project-related files and folders can be saved on a network or a local hard drive.

Revit provides a library of object families but users can create their own families of objects for specific project needs. As USACE districts complete more Revit projects, it is expected that datasets, object families, and related template standards will evolve.

Revit stores project settings in a single database without an exhaustive list of subdirectories.

Revit datasets include standards, templates, families, data, libraries, and setting files. Revit creates a default set of library folders during installation. Library folders can be created as needed to archive custom datasets.

2.3 Model Management

Model management involves the planning and designing/modeling of the building project as well as coordination and management of all the design and data files. Model management decisions are made in terms of the deliverables and life cycle workflow phases that occur in turn after model management.

2.3.1 Working in a Multiuser Environment

In a design environment, many projects require more than one person working on a model at any given time. Revit has multiple methods of accomplishing this task. While there is no absolute right or wrong method to employ, there are some considerations necessary before choosing a method to solve a design situation.

a. Linking

Linking models in Revit is a way to separate information to enable multiple users to work on the same model. Similar to a conventional CAD

method of using external reference files, linking allows the user to logically break a model into separate constituent models and work on them as needed. Revit enables the user to control visibility and display information across linked models to portray data the way the user wants it to appear.

Although there is no single correct method for linking models, there are considerations before starting them. One approach is to link different file formats in a Revit project, including other Revit models (Revit architecture, Revit structure, Revit MEP), CAD files (DWG, DXF, DGN, SAT, SKP), and DWF markup files. The specific method will be determined by the answers to questions such as the following:

- Are there separate buildings on a site or campus?
- Are there parts of the building that are being designed by different design teams?
- Is there coordination across different disciplines in-house or externally?
- Which model will the construction document be created from?
- How will changes be tracked and addressed?
- How will files be transferred to different teams or offices?

An example of a linked environment workflow, shown in Figure 3, is the linking of various disciplines for reference purposes, such as a link between the architectural and structural models.

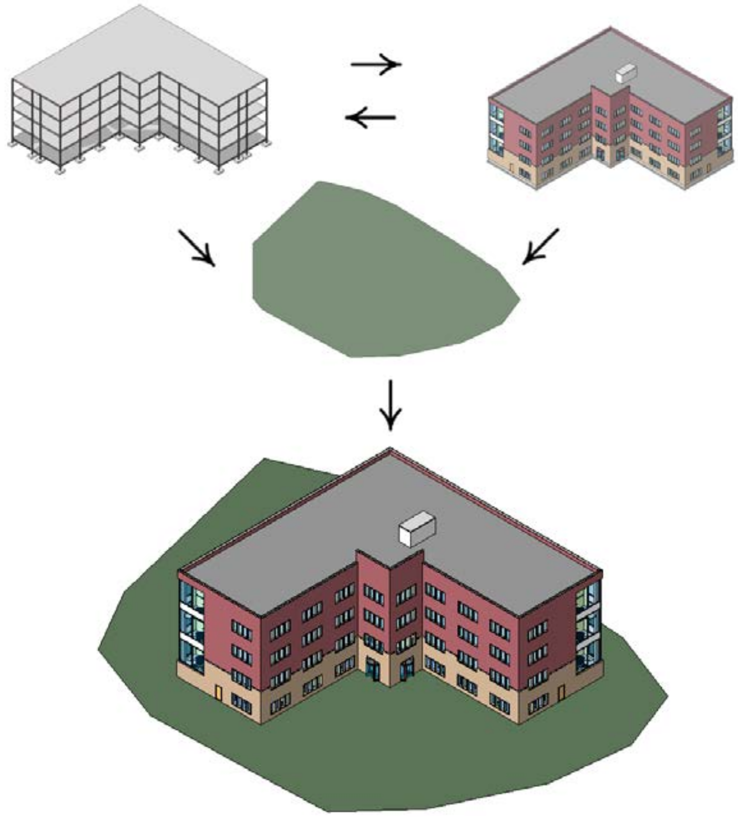

Figure 3. Linking method for a multiuser environment.

b. Worksharing Methods

Worksharing is a multiuser design method in which the project is divided into *worksets* by assigning geometry to functional groupings. In Revit there are four kinds of worksets.

- *User-created*. These allow for enormous flexibility to organize project geometry in ways previously not possible with a CAD system.
- *Families*. Each family that is loaded in the project (e.g., a plumbing fixture) is assigned to a separate workset.
- *Project Standards*. This workset type contains all defined project-wide settings such as line styles and fill patterns.
- *Views*. This workset type contains all project view worksets. For example, Floor Plan Level 1 view is assigned to a workset called "View: Floor Plan Level 1." View worksets contain view properties and any view-specific elements, such as annotations, dimensions, or text notes. When you add view-specific elements to a view, they are automatically added to the appropriate view workset.

In a traditional CAD workflow, the user thinks at the workplane level, such as 1st Floor Partition Plan, 2nd Floor Plumbing Plan, or 01 Top of Footing. Each workplane consists of a separate file and the user opens these individual files to work on objects at the workplane level. In a worksharing environment, the user thinks more about the objects that are needed to get the design completed. For example, elevator lobby, stair tower, atrium, core restroom layouts, classroom furniture layouts, site, are all examples of ways to organize worksets. Notice that none of these worksets explicitly call out what level they are on. This capability provides great flexibility in model organization and is clear to the user what objects will be contained in each workset.

A real world example could be the stair tower and the core restroom layouts. In the stair tower workset, there may be stairs, railings, landings, stair walls, and doors. In the core restroom workset, there may be the water closets, urinals, vanities, ceilings, and lighting for all floors of the building.

Worksets work similarly to a library book. The user checks out worksets. Once you take possession of a specific workset, other users cannot edit the objects in them. This is why worksets take careful planning and management. It is possible to check out more than one workset.

An often-asked question is how two people work on the same object. Using the scenario above, if a user is working in the stair tower workset that contains the shaft wall that is common to the core restrooms, who gets control of the wall? Depending on what each user needs to do with that wall may determine which workset that wall needs to be in.

Even on a modest project of one or two users, initiating worksets allows other team members to help complete a project's documentation without interrupting the workflow. Initiating worksets earlier rather than later avoids having to stop work to assign elements to specific worksets.

While there is no one correct method for worksets, there are considerations before starting them.

- How many people will likely be working on the project at the same time
- What are their roles and areas of specialization
- How complex is the project

- What is the best way to organize worksets in a manner that reflects the various building relationships as well as the project team
- Is the project team creating the actual building geometry, or placing components with regard to geometry placed by others (as with a furniture plan)

It is also important to name worksets clearly. For example, a workset named "Elevator Shaft" indicates to the other team members which elements are likely to belong to that workset, but a workset named "Temp" is too ambiguous for other users to understand.

c. Holistic Workflow

Below are two examples of a holistic workflow process. These methods may be used independently or concurrently. Many project managers use both.

Using Revit, a traditional CAD workflow of reference files can still be used. With Revit, the capabilities of CAD software also can be extended with the "checking out" of worksets, visibility across disciplines, calculation of quantities, and assembling of a complete construction document. While each of the methods outlined previously has a specific use, the combination of both can solve any design scenario.

Example 1

A firm is responsible for shell, core, and interior fitouts. The architecture group in the firm will have a shell and core version of the model. The users will create worksets based on their needs for the design of the shell and core (see Figure 4). These could include exterior walls, atrium, vestibule, elevator shaft, stair tower, etc. The interiors group would link the architecture model into an interiors model. They would also have worksets for interior partitions, core restroom finishes, elevator lobby, furniture layout, etc.

Through linking, each group's model avoids being "weighed down" by all of the geometry and information that pertains to their work phase, while at the same time they can see changes in that geometry and respond as needed.

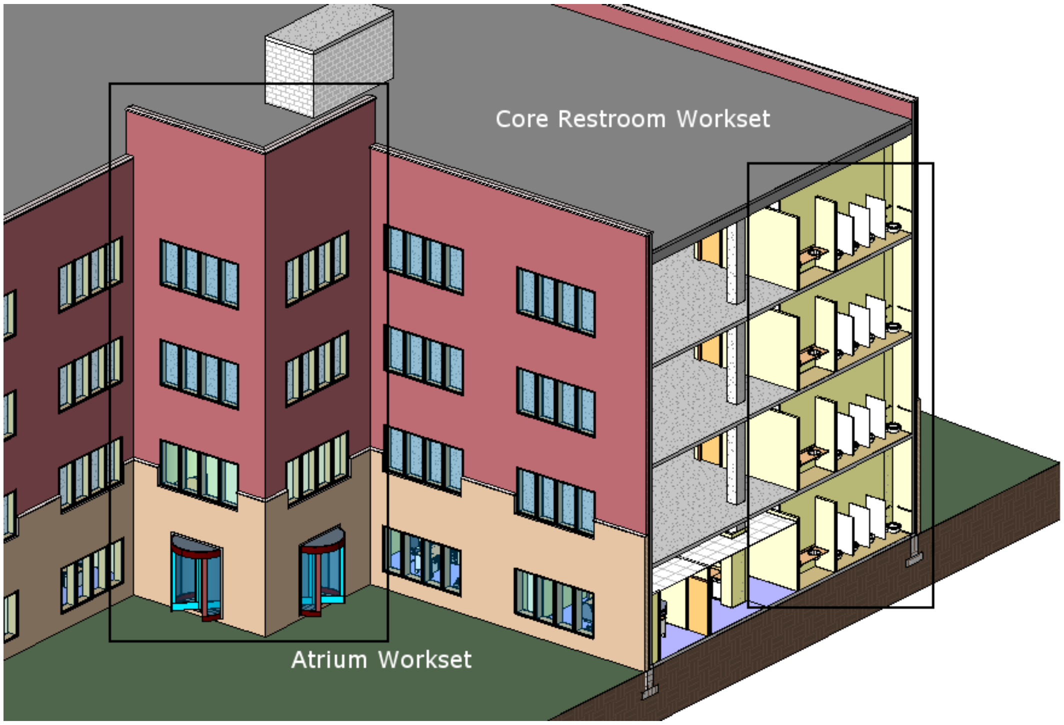

Figure 4. Multi-floor worksets.

Example 2

Firm A is responsible for all architectural elements. Firm A will be working with Firm B (structural engineers), Firm C (mechanical and plumbing engineers), Firm D (electrical engineers), and Firm E (civil engineers). All firms will have their own discipline-specific version of the model and will link to other models as needed to coordinate.

The mechanical and plumbing engineer may need to link to the structural model to ensure there are no conflicts where, for example, flex duct clashes with structural steel. The plumbing engineer may need to gain access to the plumbing fixtures for LEED (Leadership in Energy and Environmental Design) credit calculation. The electrical engineer may need to create panel schedules based on the number of electrical devices. And the civil engineer will need to calculate cut and fill for the site.

More often than not, each discipline also will use worksets so multiple people within the firm can efficiently work on the same project concurrently.

2.3.2 Designing/Modeling

Typically, designing and modeling involves three phases*: Programming/Schematic Design, Design Development,* and *Construction Documents.*

As a project evolves, so will the model components. What might seem critical at the beginning of the Programming/Schematic Design phase**,** for instance, may diminish in importance later on. Finally, as a project progresses through the Design Development phase to the Construction Documents phase**,** the initial project/building flexibility will give way to narrower constraints. At this point, emphasis on the coordination of the building model will shift toward an emphasis on the annotation and coordination of the construction document set. The three primary design phases are outlined below.

a. Programming/Schematic Design Phase

During programming and schematic design, it is important to maintain flexibility. Establish the important parameters of the building, such as floor-to-floor heights and intersections of walls/roofs/floors/ceilings, circulation spaces, programmatic requirements, and structural grids. Specific details like mullion widths and exact material assignments can wait until decisions are more final.

Functions, spaces (and the elements that define them), need to be located during the Programming/Schematic Design phase. As is often the case, too much specificity is not necessarily a good thing. Adding unnecessary elements and details to the model can increase the file size as well as the rendering time.

In the project template, consider creating and assigning a generic material assignment to a generic class of common family elements such as doors, windows, or structural elements, Also, consider creating a generic class of common host elements such as floors, walls, roofs, stairs, and railings. This will allow the project team to create and place content with a sense of confidence that the intent of the design is being resolved, while not being overly specific.

This process is illustrated by the following series of images. The image on the far left shows generic objects (translucent) and the consecutive images

show more and more specificity added to the model as more information (object type, materials, color) becomes available through the progression of design.

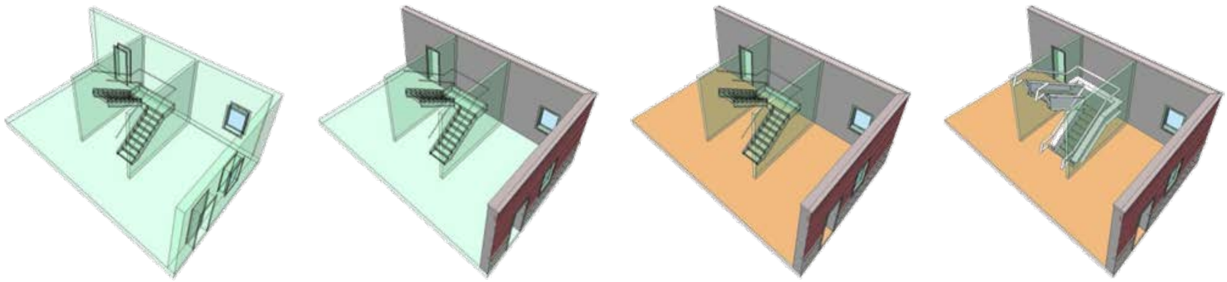

Figure 5. Progression of design model specificity.

The following tips will help to facilitate the Programming/Schematic Design phase:

- Integrate site/landscaping features, which visually complete the rendered view of the building and its context and compensate for the lack of material detail.
- Produce grayscale renderings, which do not yet have materials assigned, or convert color images to grayscale. Grayscale renderings will allow the design team and consultants, as well as the client, to concentrate on conceptual issues such as spatial/formal relationships, function, void, translucency, transparency, light, and shadow without requiring detailed decisions about materials or finishes
- Produce AVI walkthroughs in hidden line or shaded view mode. These can be produced very quickly (minutes rather than hours or days of processing time) as they do not require rendering.

b. Design Development Phase

An opportune time to set up sheets and views is just before starting the design development phase. Determine the sheets required for the final deliverable and facilitate assembling drawing sheets at later stages. Determine scale and visibility issues, arranging/naming views, and assign sheet names and numbers. This way, as the model is developed and views are created, they can be placed immediately on the appropriate sheets. Although the views will be initially incomplete, the views on the sheets will update automatically as more detail is added to the model.

Document sets are organized numerically, which eliminates the need to rely on any particular view naming convention. Simply double-click on a sheet to see all the views on that sheet or toggle down the contents of the sheet and double-click on the view itself.

As the project progresses further into design development, the model will have more constraints. Pay attention to elements that share constraints, but exist in different families. For example, when editing finished floor levels, the related walls will stretch, but the stairs will have to be updated. Revit will send an alert when there are any conflicts. The warning can be ignored and attended to later (using the Review Warning dialogue in order to remember the specifics). At other times, it will be preferable to stop and resolve the condition before moving forward.

Design development is the time to establish the core family components required although family components need not be fully developed before they are located throughout a project. Once the most essential form and type parameters are in hand, the family can be loaded and placed in the model. Family components can always be further refined and developed in the *family editor* then reloaded into the project. When reloading, all previous instances of a definition will be overwritten with the new family while the existing location and orientation are maintained.

c. Construction Documents Phase

The Construction Documents Phase focuses on detail development.

Emphasis will tend to move from project model relationships to the project model details that will be required in the deliverables.

To create a detail drawing, there are a number of options: (1) Use the 3D model, (2) create a detail from scratch using Revit's 2D tools, or (3) import existing standard details in DWG/DGN/DXF formats, directly into callouts and drafting views, to use as a starting point within the project.

Detail views can also be managed by linking to details that have been drawn in other applications. Revit will manage and coordinate the document set, including details that are produced in other applications (such as MicroStation) and linked to the Revit model.

Detail drawings can be exported (or batch exported) to DWG/DGN/DXF formats for inclusion in other applications or linked/imported to other Revit projects. The sharing or transfer of detail drawings from one project to the next is a timesaving and important function. Information sharing and collaboration is an important part of the Revit workflow.

It should be noted that project teams embarking upon their first Revit project, may employ a “hybrid” BIM process supplemented by traditional 2D CAD drafting. Using lines and fill patterns to clarify a detail is often preferable to over-detailing the 3D geometry.

During the Construction Documents phase, prepare final sheet views with design and data information including schedules, tables and charts. Many schedules are automatically generated by Revit based on object properties, but custom schedules can be created.

2.3.3 Quality Assurance and Controls

Revit automatically informs users of any conflicting design or data issues by displaying an alert message on the screen. The user can override the collision prompt and continue working, but for purposes of good quality assurance (QA), conflicts should be addressed as soon as they occur.

In addition Revit includes a built-in interference checker that can be run on a regular basis. The interference checker generates a report noting undesired intersections between elements of different disciplines. Revit provides an option to select some or all categories for interference checking. Some examples of elements that can be checked for interference include:

- structural columns and architectural columns
- structural braces, doors, and windows
- roofs and floors
- structural beams and walls.

Additionally, Autodesk’s Navisworks can be used for Revit model quality control (QC) and/or to coordinate it against a federated set of models that make up the whole project. Navisworks is especially useful when not all discipline-specific models originate in Autodesk Revit. For example, Navisworks can be used to coordinate and clash-detect models authored in AutoCAD MEP against models authored in Revit Structure, Bentley Archi-

tecture or Tekla Structures. Navisworks is also well suited for investigating soft clashes such as operational clearance buffers around MEP equipment.

2.4 Deliverables

Revit can produce deliverables in various file formats. This section describes the available formats and delivery options.

2.4.1 Soft Copies

In this document, electronic or digital files are referred to as soft copies. Revit soft copies and files can be delivered on media such as DVDs (digital versatile discs).

The Revit interface allows the user to look at model files in many different views. Some views are for visualization purposes and other views, called sheet views, are for printing purposes. Sheet views include plans, elevations, sections, details, and schedules.

Revit sheet views can be exported to DGN, DWG or DWF file formats. During export, a CAD-based layer mapping, as well as lineweights, can be applied for CAD standards compliance. Revit sheet views that are converted to DWF formats can then be viewed, marked, archived, and/or printed as hard copies.

If required, sheets with data in their native file format can be embedded in the Revit model. If required, the Revit model can be exported to an open-source standard file format such as International Foundation Classes (IFC) or gbXML.

Intelligent data for facility management purposes can be added to the Revit model. The embedded data can then be published from Revit to databases, spreadsheets, or COBie schedules.

Support files or data used to create a Revit model are referred to as the dataset. The dataset (resource files) contains project-specific information such as standard and custom library folders (template, titleblock, object, etc.) and mapping tables (color and lineweight). This information is not typically part of a project deliverable but it may be required on occasion Customized Revit settings can be saved as text-based (.ini) files and transferred electronically. Schedules and specification data embedded in a Revit model can be published to database files such as MS Access.

2.4.2 Hard Copies

Revit sheets can be printed directly from Revit to the printer or a set of DWG, PDF, or DWF files can be created from the sheet model views and the DWG, PDF, or DWF files can then be sent to the printer for printing hard copies.

Revit can publish schedules and specification data to spreadsheets, which can then be printed as hard copies. Hard copy output can be expedited using batch printing capabilities. Creating a folder for batch prints (located in the respective project directory) and directing subsequent batches to the same location allows old prints to be quickly replaced by newer ones.

2.5 Life Cycle

The data created and stored during the phases of a Revit project will continue to be useful throughout the entire building life cycle.

2.5.1 Archiving Data

At the conclusion of a project, all files and data can be archived on media, such as CDs or DVDs. Electronic data can also be archived on a server using applications such as Bentley ProjectWise.

2.5.2 Enterprise Data Library Updates

When a project concludes, verify and update the enterprise Revit data library for any new custom content such as materials, families, details, host elements, schedules, or standards that were created during the project.

2.5.3 Commissioning/Operations and Maintenance

Building commissioning is a systematic and documented process of ensuring that the owner's operational needs are met, building systems perform efficiently, and building operators are properly trained.

The Revit model addresses the entire building life cycle. Utilizing Construction Operations Building Information Exchange (COBie) technology, Revit supports maintenance operations and building management. As more innovative tools and solutions become available, the Revit model will increasingly benefit end users such as facilities operations and maintenance personnel. Because all data related to equipment (manufacturer’s

name, model number, installation date, warranty, etc.) are defined in the model, maintenance personnel could, for example, obtain information about lighting, fixtures, and electrical systems for replacement and repair.

3 Revit Resources

3.1 Revit Best Practices

Reducing file size will increase processing and image loading speed while working in Revit. Highlighted below are some best practices recommended to reduce file size and expedite the Revit workflow:

- Establish a common project coordinate system.
- Agree to common project units and dimension rounding conventions.
- Determine who is going to design and manage key common elements in the model (level, grid, load bearing wall, etc.).
- Ensure compatibility of file types between all parties and agree on use of specific software versions and future software upgrade process.
- Minimize the use of Revit in-place families.
- Maintain fewer and only essential links.
- Link only in appropriate view. For example, a detail should be referenced to a detail view.
- Use graphical symbols whenever detailed modeling is not required, such as for plumbing fixtures, furniture, etc.
- Avoid use of extensive details (on railings, extensive fences, separation systems, etc.) unless necessary. Determine appropriate level of data granularity.
- Minimize the use of void forms when modeling.
- When modeling, use families rather than groups.
- Avoid exploding geometry unless necessary.
- Delete unused groups.
- Purge model files on a regular basis.
- Address Revit warnings when they appear. (Avoid delay in resolving the warnings.)
- Create and use a default view with minimum information.
- Set model view depth to a minimum.
- Eliminate unnecessary views from model files.
- When possible, use *wireframe* or *shading view* option instead of *hidden* or *shading with edges* view.
- Turn off shadow when not necessary for viewing.
- Avoid using volumes unless necessary.
- Always use the *checkout* feature to protect and save changes made to files.

- Before using the *sync to central model* function, always use the *reload latest* function to view latest changes.
- Close and reopen Revit often throughout the day and particularly before printing. This allows the program to refresh the data and run more efficiently.

3.2 Revit Knowledge Base

3.2.1 Autodesk User Community

- Autodesk University Online: http://au.autodesk.com/?nd=home
- Autodesk Users Group International: http://www.augi.com
- Autodesk Discussion Groups: http://discussion.autodesk.com/forums/
- Autodesk User Help Information: http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=1068444
- USACE Revit Case Studies: http://usa.autodesk.com/adsk/servlet/item?siteID=123112&id=13136284

3.2.2 Revit User Community

- Revit Community: http://www.augi.com/revit/default.asp
- Revit & Legacy Cad Interoperability: http://www.autodesk.com/revit
- Revit City (User group and Revit-related resources): http://www.revitcity.com/
- Revit Library: http://revit.autodesk.com/library.asp
- Revit Videos: http://www.youtube.com/user/autodesk#p/c/E88CCF78D5DF07E4/6/U3WIusMW454

3.2.3 USACE User Community

- USACE Technical Excellence Network's BIM Sub Community of Practice (COP): https://ten.usace.army.mil/TechExNet.aspx?p=s&a=CoPs;14 (secured network)

3.3 Revit Support

For additional issues related to Revit technology and implementation, refer to:

- CAD/BIM Technology Center: https://cadbim.usace.army.mil (secured network)
- ACE-IT online information: https://aceit.usace.army.mil (secured network)

- System Requirements for Revit:
  http://usa.autodesk.com/adsk/servlet/pc/index?siteID=123112&id=12431819

3.4 Sample Revit Training Program

TRACK 1: DESIGN TEAM TRAINING CURRICULUM

Track 1 provides the core BIM capabilities. Track One focuses on BIM fundamentals and project-based workflows serving as the foundational understanding of the Autodesk BIM software and best practices. Project team collaboration methods are emphasized throughout the training.

BIM FUNDAMENTALS

This training is targeted for users with minimal or no BIM experience. No previous CAD experience is necessary. The course introduces students to BIM concepts and the Revit tools for parametric building design and documentation.

This course is covers the following areas: Understanding the User Interface: Tools and techniques; Basic Modeling and the Use of Drawing Aids; Model Views; Developing a Project; and Importing and Exporting Files.

Training Period: Four days of training

Work Location and Required Facilities: On-site at USACE location

BIM PROJECT START TRAINING

This training enables project teams to identify production workflows and use the software effectively to start their project. Autodesk will provide targeted essentials and advanced product training. The training will be delivered using out-of-the-box software, referencing Autodesk Official Training Courseware (AOTC).

Training will be provided for a maximum of 10 trainees per class.

Training Period: Four days of Essentials Product Training

Work Location and Required Facilities: On-site at USACE location

BIM PROJECT ASSESSMENT & REVIEW

Once fundamentals of the BIM application software are understood and the initial project setup has begun, the assessment will define the BIM project strategy for the design team on a selected project.

Autodesk will use on-site interviews to conduct the assessment. Consultants will prepare the agenda and presentation materials for the information-gathering interviews. They will then provide a written action plan summarizing product use recommendations, implementation actions, training curriculum, content, and schedule.

The project assessment will review project goals and design requirements, current and proposed resources, team organizational structure, and existing data; review existing team project model files; and provide input on best practices and recommended modeling approach.

Training Period: Five days consulting, including:

- One day of on-site information gathering for project assessment and action plan by two Autodesk consultants
- One day of off-site review of project data
- Two days for completion of project assessment documentation

Work Location and Required Facilities: On-site at USACE location, and remote via conference call

BIM PROJECT OPTIMIZATION & CONFIGURATION

With BIM fundamentals and a BIM action plan in place, Autodesk will work with the project team to set up the project model, including team model-sharing basics, content, and configuration (e.g., view setup for floor, ceiling, equipment plans); to assess the application; and to provide optimization and configuration support to the team according to best practice recommendations.

Typical project standards set up during this stage may include worksets, family creation guidelines, styles, views, components, sheets, titleblocks, and project templates.

It is possible that not all of the content will be migrated to the new menu system/user interface within the days allocated for this task. The goal is to migrate sufficient content and resources for the Pilot Project and allow USACE to continue the migration as needed.

Training Period: Four days consulting

Work Location and Required Facilities: On-site at USACE location

Resources: Autodesk Project Consultant

BIM PROJECT MENTORING & ADVANCED TRAINING

Once fundamentals of the application software and BIM standards are understood, the project team strategy is in place, and BIM objects have been created, this knowledge will be applied to a selected project.

The consultants work closely with project team members as they continue their project. The mentoring can take the form of over-the-shoulder, additional project team and/or advanced training, and might include additional “lunch ‘n learn” lecture-style training as well.

Mentoring activities should be timed to prepare the team for major deliverables. Workflow will be set up to compose the model data from extended project team, with import/export of project data from all disciplines and team players. Input will be provided for leveraging model data for sustainable design, constructability, cost, schedule, owner benefits, etc.

Training Period: Four days consulting

Work Location and Required Facilities: On-site at USACE location, or remote via conference call

TRACK 2: PROJECT BASED BIM MANAGERS TRAINING

Track 2 focuses on methods to oversee and assess project BIM deliverables, for process improvement and quality. Project team-collaboration methods are stressed throughout the training.

BIM PROJECT START TRAINING

The intent of this training is to enable USACE's team to use the software to effectively start their project and identify production workflows.

Autodesk will provide Targeted Essentials and Advanced Product Training. The training will be delivered using out-of-the-box software, referencing Autodesk Official Training Courseware (AOTC). Autodesk will work with USACE to determine appropriate AOTC curriculum.

Training will be provided for a maximum of 10 trainees.

Training Period: Four consecutive days of Essentials Product Training

Work Location and Required Facilities: On-site at a USACE training space

BIM PROJECT HEALTH CHECK PROGRAM

Autodesk provides a health check that presents the findings of a project's health and provides guidance on next steps and necessary model enhancements. The purpose is not only to monitor a project but also to train USACE personnel to conduct their own health checks on subsequent projects. Additional documentation may address best practices and project workflow procedures.

Autodesk will evaluate files and models across disciplines for completeness, issues created, and adherence to best practices.

Training Period: Five days total. Each health check will consist of:

- One day of on-site consulting
- Followed by four days of off-site project review and documentation

Work Location and Required Facilities: On-site at USACE location, or remote via conference call

BIM PROJECT QUALITY ASSURANCE METHODS

Based on the health check reports of BIM models, this quality assurance curriculum provides instruction to BIM managers on BIM review practices and procedures with both interactive and batch software tools. This training will include instruction on methods to validate BIM models received from design teams, checking for accuracy and consistency in modeling methods and data attribute consistency. This quality check will be matched against existing agency standards to demonstrate variance. The intent of this training is to establish standard quality assurance methodologies.

Training Period: Three days total, including review of health check reports consisting of:

- One day of on-site consulting and review of health check
- One day of on-site training on interactive QA methods
- One day of on-site training on batch mode QA methods

Work Location and Required Facilities: On-site at USACE location

Prerequisite: BIM Project Health Check Program

BIM PROJECT REVIEW FOR MANAGERS (NAVISWORKS) TRAINING

Navisworks training will allow project managers to detect and resolve issues in design coordination and construction sequencing. This training will demonstrate how project managers can aggregate BIM models from all subcontractors and mediate conflicts.

Training Period: Three days total, including review of health check reports, consisting of:

- One Navisworks orientation, process evaluation, model reviews
- One day of on-site training on clash and collision detection
- One day of on-site training on 4D simulations, reporting, database linking

Work Location and Required Facilities: On-site at USACE location

Prerequisite: BIM Project Health Check Program

3.5 Revit Glossary

This glossary defines many terms commonly used in Revit or when working with Revit.

ADSK. Autodesk Exchange File, the file format used by Autodesk applications to transmit design information.

Block. An AutoCAD feature, which can be composed of *objects* on several layers with various properties.

Buzzsaw. An online collaboration service from Autodesk. Buzzsaw users can store, manage, and share project documents from any internet connection, thus enhancing team productivity and reducing costs. Revit publishing tools can save sheets and views as DWG or DWF files, and then upload these to a Buzzsaw project site in one step.

Central File. Also known as a master project file. Central files are used for worksharing. The central file stores the current ownership information for all worksets and elements in the project and acts as the distribution point for all changes published to the file. All users should save their own local copy of the contents of the central file, edit locally in this workspace, and then synchronize with the central file to publish their saved changes so that other users can see their work.

Communication Center. A tool that displays links to information about product updates and announcements.

Component. A building element that is usually delivered and installed on site, rather than built in place. (Also referred to as a hosted component.) For example, windows, doors, and furniture are components. In contrast, walls, floors, and roofs are built in place; these are called hosts or host elements.

Detail Component. A 2D element that can be added to a detail view or a drafting view. For example, to add a metal stud or shim to a drafting view, Revit provides over 50 detail component families; based on 16 CSI divisions. Detail components can also be custom created.

DWF. Design Web Format, the Autodesk file format for publishing design data. DWF offers an alternative to generating PDF (Portable Document

Format) files. DWF files are significantly smaller than the original RVT files, making them easier to send by email or to post to a web site. Recipients can view DWF files using Autodesk DWF Viewer.

DWG. A drawing file format supported by AutoCAD and other CAD applications. Revit can import and export DWG files.

DXF. Drawing Exchange Format. An open file format that is supported by many CAD applications, including Revit. A DXF file is a text file that describes a 2D drawing. The text is not encoded or compressed, so DXF files are generally large.

Element. An individual item in a building model. Revit projects use three types of elements: (1) Model elements represent the actual 3D geometry of a building. For example, walls, floors, and roofs. (2) Annotation elements help to document the model. For example, dimensions, text notes, and section tags. (3) Datum elements are non-physical items that are used to establish project context. For example, levels, grids, and reference planes.

Element Borrowing. A Revit function for workshared projects. Element borrowing allows a user to edit an element in a workset that he or she does not own. If another team member is currently editing the workset, the team member is the owner of the workset and another user must place a request to borrow an element. If no one owns the workset, permission to borrow is automatically granted.

Export. To convert information from a Revit project to another format, for use with another software application.

Family. A class of elements in a category. A family groups elements with a common set of parameters (properties), identical uses, and similar graphical representations. Different elements in a family may have different values for some or all properties, but the set of properties (their names and meaning) is the same. For example, a family of concrete round columns contains columns that are different sizes. Each column size is a type within the Concrete Round Column family.

Generic Model. A generic model is a *family template* in Revit, which consists of previously set parameters, which can be modified by the user.

Group. A defined set of elements that can be placed as a unit in a building design. Grouping elements is useful when there is a need to create entities that represent repeating units or are common to many building projects (e.g., repeating floors).

I-Drop. An Autodesk feature that allows users to drag and drop content from a web page into a Revit session. It allows designers and developers to create web pages that can easily be dragged and dropped into Autodesk design products that are i-drop enabled.

Import. To bring information from another source into a Revit project. For example, to import DWG files created using a CAD application (such as AutoCAD).

In-Place Families. Custom elements, created in the context of a project. In-place families are created when a project requires unique geometry that is not expected to be reused or geometry that must maintain one or more relationships to other project geometry.

Insertion Point. When a block, family, or and external object is inserted, Revit creates a reference point (which can be modified later) that specifies its location, scale, and rotation.

Key Schedule. A table of information that the user can create to simplify or automate data entry in other, larger schedules. A key schedule reduces the time required to produce larger schedules and helps generate accurate cost estimates. For example, a room schedule for a dormitory building might list 100 rooms with the same floor, wall, and base finishes. In a key schedule, room style keys may be defined, such as public, service, and units. Each key specifies different floor, wall, and base finishes for its room style. Rather than manually specifying finishes for all 100 rooms, the user can assign a room style to each room. When the room schedule is created, fields in the schedule automatically update with the appropriate finishes, based on the assigned room style keys.

Label. A text placeholder added to tags or titleblocks. Labels are created as part of a tag or titleblock family, in the family editor. Later, when the tag or titleblock is placed in the project, the label is replaced with the actual value for that instance.

Layer. In Revit, layer information is embedded in object properties. A drawing in AutoCAD can be made up of different layers.

Library. A collection of predefined resources that may be used in a Revit project. For example, a user may access libraries of templates, detail components, families of model elements, and annotation elements.

Line Styles. Line styles are used to indicate different effects. For example, a dashed line (------) can represent a reference plane. Several line styles are available when Revit is installed. Each predefined line style has a name that describes either the line (e.g., dash dot), or where Revit uses the line style (e.g., sketch lines). In Revit, line styles are stored in a template file.

Lineweight. Lineweight or the thickness of an object's lines in AutoCAD and Revit can be controlled in both the drawing display as well as in plotting.

Linking. Revit architecture, Revit structure, and Revit MEP models may be linked. Linking Revit models is primarily intended for linking separate buildings, such as those that compose a campus. Revit can also link 2D AutoCAD models.

Load. To transfer a file or a collection of information into a Revit project. In Revit, this includes groups, templates, detail components, materials, families of model elements, annotation elements, and other project information.

Model. A 3D graphical representation of design elements or objects.

Navisworks. An Autodesk product that provides a comprehensive set of tools for large-scale model visualization and optimization, and aggregates data from multi-disciplined models. It helps detect and resolve problems early in the design process. It facilitates collaboration, thereby accelerating design and review cycles.

ODBC. Open Database Connectivity (ODBC) is a general export tool that works in conjunction with many software drivers. You can export information about model elements in a Revit project by exporting to an ODBC database.

Parameters. User-defined fields added to multiple categories of elements, sheets, or views in a project. These parameters are specific to the project. For example, a project parameter named "Approved By" may be created for views. In the properties for each view, the value for this parameter may be entered to indicate who approved the view.

Plotting. Printing in Revit. A view represents a plotted (or printable) page. Any number of views can be created. Each view is saved in its own tab and can be associated with a different page setup that will determine how it will print (or plot).

Project Standards. Settings that may be applied to a project. Project standards include family types, lineweights, materials, view templates, and object style.

Project Template. A set of initial conditions for a project. Revit provides several stock templates, and new templates can be created as necessary for specific projects. Any new project based on a template inherits families, settings (such as units, fill patterns, line styles, lineweights, and view scales), and geometry from the template. Templates use the file extension RTE. (See Template.)

Publish. Distribute a file by placing it in a central or shared location. Projects can be published as DWG or DWF files on Autodesk Buzzsaw (web-based application).

Reference Planes. An integral part of family creation. Reference planes act as graphical guidelines when modeling. Reference planes appear in plan views.

Rehost. To move a component from one host to another (e.g., the Rehost tool may be used to move a window from one wall to another).

Rendering. The process of generating photorealistic illustrations of a building design. Rendered images are often used to present building designs to clients. Revit renders 3D project views with various effects, such as lighting, plants, decals, and people.

RFA. The file format (or file extension) for a Revit family.

RTE. The file format (or file extension) for a Revit template.

RVT. The file format (or file extension) for a Revit project.

Schedule. A tabular display of information. Schedules are extracted from the properties defined in model elements and displayed in schedule views. Many types of schedules may be created, including quantities, material takeoffs, annotation schedules, revision schedules, view lists, and drawing lists.

Shared Parameters. Shared parameters are parameters that can be added to families or projects and then shared with other families and projects. Specific parameters can be added that are not predefined in the family file or the project template.

Subscription Center. The subscription center provides access to information about subscription services such as product enhancements, web support from Autodesk technical experts, and self-paced e-Learning.

System Families. Predefined and preloaded families in Revit are saved in templates. System families contain family types used to create basic building elements such as walls, floors, ceilings, and stairs. They also include types for elements (such as levels, grids, sheets, and views).

Template. A collection of settings to use as a starting point for projects, families, views, and more. (See Project Template, View Template.)

Titleblock. A template for a sheet. A titleblock includes general information, such as project address, date of project, revision history, and information about the company, agency, or organization.

Type Catalog. A list of model elements that belong to a particular family type but differ in size or other characteristics. Using type catalogs, only the size can be loaded, not the entire family type. For example, if detail components for wood framing need to be loaded for detail views, rather than loading 32 sizes of cut lumber, only the sizes needed are selected. By using the type catalog, project size is reduced and the number of items listed in the type selector for that family is limited.

View. A representation of a building model. A Revit project file contains a database of information about a building model, and a view is one way of looking at that information. The project browser lists the available views for a project. These can include floor plans, ceiling plans, elevations, sections, detail views, drafting views, 3D views, walkthrough views, legend views, schedules, renderings, and sheets.

View Template. A collection of view properties, such as view scale, discipline, detail level, and visibility settings, that is common for a view type (such as plan or elevation). The user specifies the value for each property in the template. For example, a view template can be created for a structural floor plan, and another view template for an exit floor plan. These templates can then be applied to different floor plans to display information in each plan according to its purpose. (See Template, View.)

Working Units. The units of measurement that are to be used in the project, which are determined before project inception. Revit allows users to set the format, precision, and other conventions to be used in coordinates and distances.

Workset. A collection of elements, such as walls, doors, floors, or stairs. Only one user can edit (or own) a workset at a given time. All team members can view worksets owned by other team members, but only the “owner” can make changes.

Worksharing. Allows simultaneous access to a shared model through use of a central file. Worksharing can be helpful when multiple team members are working a single model.

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14. ABSTRACT
Building Information Modeling (BIM) technology has rapidly gained acceptance throughout the planning, architecture, engineering, construction, operations, and maintenance industries. The challenge for the US Army Corps of Engineers (USACE) is to extend BIM use beyond its basic labor- and time-saving benefits to become a fully realized information network that permanently transforms conventional business processes to unprecedented levels of efficiency and organization.

This document describes the current USACE strategic plan, reflecting progress made toward the goals of the original 2006 USACE BIM roadmap as published in Engineer Research and Development Center (ERDC) Technical Report TR-06-10 (October 2006). This update of the strategic roadmap focuses on fuller integration of BIM technologies into USACE planning, design, construction, and operations and maintenance (O&M) processes. It describes how USACE will meet or exceed the vision of its customers, including the Office of the Secretary of Defense (OSD), the Army, and the Air Force. The scope of this plan is BIM implementation within the business processes of the Military Construction (MILCON) and Civil Works programs, including processes for working with USACE industry partners and software vendors.

15. SUBJECT TERMS
modeling, planning, design, construction, operations and maintenance (O&M), Military Construction (MILCON), construction costs, building life cycle

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